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ON THE APPLICATION OF MONTE CARLO METHODS TO PROBLEMS IN NEUTRON AND GAMMA-RAY TRANSPORT THEORY

AV

MARTIN LEIMDÖRFER

GÖTEBORG 1964

CTHB
22 APR. 1964
GÖTEBORG

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AKADEMISK AVHANDLING

SOM MED TILLSTÅND AV CHALMERS TEKNISKA HÖGSKOLA FRAMLÄGGES TILL OFFENTLIG GRANSKNING FÖR TEKNISK DOKTORSGRADS VINNANDE LÖRDAGEN DEN 23 MAJ 1964 KL. 10 Å FÖRELÄSNINGSSALEN I ADMINISTRATIONSBYGGNADEN, SVEN HULTINS GATA, GÖTEBORG.

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This thesis consists of eight papers:

I. M. Leimdörfer. *The Backscattering of Gamma Radiation from Plane Concrete Walls.* Nuclear Science and Engineering 17 (1963) 345.

II. M. Leimdörfer. *The Backscattering of Gamma Radiation from Spherical Concrete Walls.* Nuclear Science and Engineering 17 (1963) 352.

III. M. Leimdörfer. *Multiple Reflection of Gamma Radiation in a Spherical Concrete Wall Room.* Nuclear Science and Engineering 17 (1963) 357.

IV. M. Leimdörfer. *On the use of Monte Carlo Methods for Solving Gamma Radiation Transport Problems.* Nukleonik 6 (1964) 14.

V. M. Leimdörfer. *A Monte Carlo Method for the Analysis of Gamma Radiation Transport from Distributed Sources in Laminated Shields.* Nukleonik 6 (1964) 58.

VI. M. Leimdörfer. *On the Transformation of the Transport Equation for Solving Deep Penetration Problems by the Monte Carlo Method.* Transactions of Chalmers University of Technology. 286 (1964).

VII. M. Leimdörfer. *On the use of Monte Carlo Methods for Calculating the Deep Penetration of Neutrons in Shields.* Transactions of Chalmers University of Technology. 287 (1964).

VIII. M. Leimdörfer. *The Backscattering of Fast Neutrons from Plane and Spherical Reflectors.* Transactions of Chalmers University of Technology. 288 (1964).

Summary

The theoretical treatment of the transport of particles and radiation gives rise to problems of great mathematical complexity. The standard methods which are presently used to solve the transport problems that appear in reactor, accelerator, space, and weapons shielding as well as in medical radiology are often questionable. Extensive, and not always realistic idealizations have to be made to achieve numerical solutions even when using the most up-to-date electronic computing equipment. The first aim of the present thesis is to indicate the possibility of using Monte Carlo techniques as a general tool for routine calculations in photon and neutron transport theory. This has not generally been possible before as Monte Carlo work required too much of intuition and numerical experimentation to make the method practically applicable on a broader scale. The second aim of this thesis is to show, in a number of cases, the possibilities of constructing simplified mathematical models which give a satisfactory picture of the physical problem to be solved to permit approximate results to be obtained by essentially analytic means. The Monte Carlo methods were used to test the applicability of these models. The third aim of the present thesis is to give some results of problems which have not hitherto been satisfactorily solved.

Papers I, II, and III deal with the reflection of gamma radiation, and Monte Carlo results are compared with results obtained by simplified computational models. Paper IV gives an account of the Monte Carlo procedures used in the previous papers and some additional results of practical interest are shown. In papers V and VI a general method for deep penetration calculations is outlined and applications to photon problems are demonstrated. In paper VII the method is generalized with regard to geometry and applied to neutron penetration problems. In paper VIII, finally, the approach used for analyzing deep-penetration problems is shown to be efficient also for reflection problems. Results are displayed of some neutron back-scattering problems involving a variety of materials and source energies.

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